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DOMINANT DOUGLAS-FIR RESPOND TO FERTILIZING AND THINNING IN SOUTHWEST OREGON

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ABSTRACT

In 30-year-old, Site IV Douglas-fir in southwest Oregon, fertilizing increased average 4-year basal area growth of dominant trees by 57 and 28 percent on clay loam and sandy loam soils, respectively. Fertilizing with thinning increased growth by 94 and 132 percent over untreated growth. Thinning on clay loam soil increased growth by 53 percent. Treatment did not affect height growth on either soil.

Keywords: Douglas-fir, thinnings, fertilizer response (forest tree), forest management, soil management, basal area increment, southwest Oregon.

INTRODUCTION

To increase tree growth and wood production, fertilizing and thinning are being tested by several organizations in southwestern Oregon. We report the growth-stimulating effects of these treatments during the 4 years after their application to 30-year-old, Site IV Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) near Tiller, Oregon.

STUDY AREA

Location.--The study area is located 7 miles southeast of Tiller, Oregon, between the 2,500- and 3,000-foot elevations. Topography is relatively uniform with northeast aspect and slopes ranging from 20 to 35 percent. Soils in the study area are derived from volcanic tuffs and breccias but are unnamed. In the lower and major part of the study area, the soil is a moderately deep, well-drained clay loam overlying loamy clay subsoil; at higher elevations, the soil is a shallow, well-drained, sandy loam over sandy clay loam subsoil.[1/]

Stand.--The stand originated from natural seed fall about 10 years after a wildfire in 1929. When this study was established in spring 1969, dominant trees on the clay loam soil averaged 29 years old and approximately 58 feet tall; site quality was estimated at site index 120 (100-year index age). Average initial basal area (118 square feet per acre) was near normal standards; however, stand density (995 stems per acre) was about 76 percent of normal. On the sandy loam soil, site quality was slightly lower, site index 95; no direct measure of initial stand basal area and density was made; however, the stand was similar to the one on the clay loam.

Climate.-- Based on 10-year records (1963 through 1972) from two locations 9 to 10 miles northeast of the study area and also at the 2,400- to 2,500-foot elevation, annual precipitation averaged 43.5 inches with 9.4 inches (22 percent) falling during the April-through-September period.[2/] Evaporation greatly exceeds precipitation during the summer months, so trees in the study area are subjected to summer moisture stress characteristic of western Washington and Oregon.

Design and treatment.--The experimental design differed on the two soils. On the more extensive clay loam soil, it was a 2 x 2 completely random factorial with seven replications; thus, both fertilizing and thinning were compared with untreated controls as separate or combined treatments. On the less prevalent sandy loam soil, two treatments, fertilizing and fertilizing plus thinning, were compared with controls; stand and soil conditions permitted only three replications.

[1/] L. D. Herman. Detailed soil survey of Levels-of-Growing-Stock Study Area in Stampede Creek, Umpqua National Forest. Unpublished report on file, Forestry Sciences Laboratory, Olympia, Washington, 16 p.

[2/] Records provided by Jack Rothacher, Research Hydrologist, Forestry Sciences Laboratory, Corvallis, Oregon, August 1973.

Each study tree is a dominant Douglas-fir, located within or immediately outside a levels-of-growing-stock (LOGS) trial. This trial is part of a regional cooperative test of eight[3/] thinning regimes located on the clay loam soil. Control and thinned trees on that soil were randomly selected from nearby control or thinned plots of the LOGS trial. No trees were fertilized on the LOGS plots; therefore, trees outside LOGS plots were randomly assigned to a fertilizing or fertilizing and thinning treatment. On both soils, these treatments were applied within 0.05-acre circular plots centered on the chosen trees.

Treatments were applied prior to the 1969 growing season. Thinning removed approximately 70 percent of the initial number of trees and 40 percent of the initial basal area. Fertilizers containing N, P, K, and S were uniformly broadcast by hand at the rates of 300, 150, 100, and 50 pounds of element per acre, respectively. Sources of nutrient elements were as follows:

ELEMENT	SOURCE
N	Urea (46-0-0-0)
P and S	Sulfated-superphosphate (0-30-0-20)
	Triple superphosphate (0-45-0-0)
K	Potassium chloride (0-0-60-0)

Measurements.--Diameter at breast height was measured prior to treatment in spring 1969 and annually through the 1972 growing season. Total heights as of fall 1963 and 1968 were measured after the 1969 growing season; total height as of 1971 was measured in 1971. Thus, height growth data for a 5-year period before and a 3-year period after treatment were available.

RESULTS

Height growth.--There is no strong evidence that treatment affected height growth on either soil during the 3 years after treatment (table 1). On the clay loam, posttreatment growth ranged only between 5.4 and 6.1 feet among the treatment means. These differences were not statistically significant.[4/] On the sandy loam soil, both pretreatment and posttreatment growth varied more than on the clay loam. Posttreatment growth ranged between 4.0 and 6.7 feet. These differences among treatment means were not statistically significant, although they indicated that fertilizing may have reduced height growth on the sandy loam soil.

Basal area growth.--On both soils, average basal area growth of treated trees exceeded that of untreated in all years (table 2). On the clay loam soil, basal area growth was positively and significantly related to initial tree size. The seven replications on that soil permitted covariance adjustment of average posttreatment growth to a common, average d.b.h. at the start of all treatments. Orthogonal

[3/] LOGS = 8 thinning regimes vs. 1 unthinned (control).

[4/] In this paper, when differences are statistically significant, p = 0.05; when highly significant, p = 0.01.

Table 1.--*Average initial height and 3-year height growth before and after treatment of 30-year-old, Site IV Douglas-fir near Tiller, Oregon*

Treatment	Initial height, 1968	Height growth, 1964-68		Height growth, 1969-71		Ratio after/before
		Mean	S.D.[1]	Mean	S.D.	
	- - - - - - - - - - - - - *Feet* - - - - - - - - - - - - -					
		CLAY LOAM SOIL				
No treatment	57.7	8.9	1.4	5.4	1.3	0.61
Thinning	60.0	8.4	1.1	5.4	1.0	.64
Fertilizing	55.6	8.0	1.6	6.1	1.6	.76
Fertilizing plus thinning	57.7	[2]8.7	1.6	[2]5.8	1.6	.72
		SANDY LOAM SOIL				
No treatment	47.7	[3]7.5	.5	4.7	.5	.63
Fertilizing	47.7	8.7	1.7	4.0	1.7	.46
Fertilizing plus thinning	48.7	10.7	1.5	6.7	1.5	.64

1/ S.D. = standard deviation.

2/ Based on 6 not 7 trees as with other entries.

3/ Based on 2 not 3 trees as with other entries.

comparisons of these adjusted means confirmed that there was no statistically significant interaction in any year, indicating that the effect of thinning or fertilizing probably held at either level of the other treatment. The main effect of thinning (average for fertilized and unfertilized trees) was highly significant in each year (table 2) and in the total 4-year period (table 3). The statistical significance of the fertilizer effect, however, gradually decreased from highly significant in years 1 and 2 to nonsignificant in year 4. The main effect of fertilizing was highly significant in the 4-year period (table 3).

For the 4-year period, percentage gain in basal area growth on the clay loam soil averaged 53 percent from thinning, 57 percent from fertilizing, and 94 percent from the combined treatments (table 2). These percentage gains are for trees having an initial d.b.h. equal to the average for all study trees on the clay loam soil, or 8.9 inches. Percentage gains for trees of smaller diameter will be larger and those for trees with initially larger than average diameter will be somewhat smaller than these. Based on growth during the fourth growing season after treatment, continued response is predictable for all treatments.

Table 2.--*Average basal area growth per tree and relative gains over growth of untreated trees, 30-year-old, Site IV Douglas-fir near Tiller, Oregon*

Treatment	First year		Second year		Third year		Fourth year		All years	
	Growth	Gain	Growth	Gain	Growth	Gain	Growth	Gain	Growth	Gain
	Square feet	*Percent*	*Square feet*	*Percent*	*Square feet*	*Percent*	*Square feet*	*Percent*	*Square feet*	*Percent*
CLAY LOAM SOIL[1/]										
No treatment	0.030	--	0.040	--	0.016	--	0.024	--	0.109	--
Thinning	.038	27	.061	53	.029	81	.040	67	.167	53
Fertilizing	.043	43	.067	67	.028	75	.032	33	.171	57
Fertilizing plus thinning	.055	83	.078	95	.034	112	.045	88	.211	94
		[2/](28)		(17)		(21)		(41)		(23)
SANDY LOAM SOIL										
No treatment	.017	--	.020	--	.013	--	.016	--	.065	--
Fertilizing	.021	24	.029	45	.016	23	.017	6	.083	28
Fertilizing plus thinning	.036	112	.052	160	.029	123	.034	112	.151	132
		(71)		(79)		(81)		(100)		(82)

1/ Growth adjusted by covariance techniques for differences in initial average d.b.h. among treatments.

2/ Figures in parentheses show percentage gain with fertilizing and thinning over fertilizing alone.

Table 3.--*Average basal area growth per tree on clay loam soil during 4 years after treatment of 30-year-old, Site IV Douglas-fir near Tiller, Oregon*[1/]
(In square feet)

Treatment	Treatment		Average[2/]
	Unfertilized	Fertilized	
Unthinned	0.109	0.171	0.140
Thinned	.167	.211	.189
Average[2/]	.138	.191	.165

1/ Growth adjusted by covariance techniques for differences in initial average d.b.h. among treatments.

2/ The differences between the thinned and fertilized treatments and their 99-percent confidence intervals are 0.049±0.007 and 0.053±0.007, respectively. The main effects for fertilizing and thinning were each significant at the 1-percent probability level.

On the sandy loam soil, basal area growth of dominant trees was consistently less than that of control or comparably treated trees on the clay loam soil (table 2). Fertilized trees showed only slight and statistically nonsignificant gains over control trees. However, growth of fertilized and thinned trees exceeded that of control or fertilized trees in all periods, and these differences were significant in all but the fourth year (table 2).

The combination of fertilizing and thinning was much more effective than fertilizer alone, especially on the sandy loam soil. For the 4-year period, percentage gain in basal area growth of the combined treatment over the single treatment was 82 percent on the sandy loam compared with 23 percent on the clay loam. Based on growth during the fourth growing season after treatment, future additional gains on the sandy loam from the combined treatment will be substantial and those from fertilizing will be minimal.

Regardless of treatment, dominant trees on both soils showed similar yearly trends in basal area increment (table 2). Average basal area growth for all trees was depressed in the third year, 1971. This growth depression is not related to less precipitation during the growing season; in fact, both total and growing season precipitation were second highest recorded at two nearby weather stations during the most recent 10-year period. Some reduction in basal area growth by treated trees may be explained by a heavy cone crop on some of these trees; in contrast, no control trees had cones in 1971. On the clay loam soil, the difference in growth between treated

and untreated trees was greatest in the third year. On the sandy loam soil, apparent gain was greatest in the second year after treatment (table 2).

DISCUSSION AND CONCLUSIONS

This study in southwestern Oregon, like numerous field trials in western Washington and northwestern Oregon, demonstrates that fertilizing or thinning or both significantly increase growth of Douglas-fir. Since response has not yet ended, a longer period of observation is necessary before the final benefits or gain from treatment can be measured and evaluated.

Increased growth resulted from combining several fertilizers supplying N, P, K, and S at rates of 300, 150, 100, and 50 pounds per acre, respectively. We do not know which of the nutrient elements or combinations corrected the growth-limiting shortage at this site. Since supplying nitrogen in a complete fertilizer more than doubles the cost of comparable urea treatment, choice of fertilizer has practical significance to the land manager. In addition to continuing growth measurements in the study area, we plan chemical analysis of foliage from fertilized and unfertilized trees to indicate gross nutrient shortages or imbalances among the nutrient elements tested.

Fertilizer tests in a nearby area suggest that nitrogen is probably the nutrient element that most limits growth. In a thinned stand 11 miles north and with similar stand and site conditions, 5-year basal area growth of dominant trees treated with 200 pounds of N was 96 percent of that of trees treated with equal amounts of N but with additions of P, K, and S. This difference was statistically nonsignificant.[5/]

Initial trends of basal area growth suggest that the long-term effect of thinning on diameter growth of dominant trees may exceed that of fertilizing in our study area. On both soils, the stimulating effect of the fertilizer-only treatment declined rapidly after the third growing season. In contrast, growth of fertilized and thinned trees or thinned-only trees (on the clay loam soil) was maintained at much higher levels. The apparent shorter duration of the fertilizer effect could indicate that nutritional levels for the subject trees are returning to their original levels. Alternatively or additionally, the fertilizer treatment may have stimulated the growth of nearby trees so that increased competition is more rapidly reducing the diameter growth of fertilized but unthinned subject trees.

There is considerable practical interest in determining if and where the effects of the combined treatment, thinning plus fertilizing, will provide a larger increase in growth than the theoretical addition of their separate effects. In this study, the average increase in basal area growth on clay loam soil during the first year after

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5/ Unpublished data on file at the Forestry Sciences Laboratory, Olympia, Washington.

the combined treatment was 83 percent; yet the sum of the separate effects of thinning (27 percent) and fertilizing (43 percent) was 70 percent (table 2). This suggests a more-than-additive or synergistic effect when the treatments are actually combined. However, in each of the following 3 years and in the total period, the effect of the combined treatment was less-than-additive or antagonistic. These comparisons suggest initial positive and subsequent negative interaction between the thinning and fertilizing treatments at this location. However, our statistical analyses indicated that these apparent interactions, thus far, are likely due to chance.

Additional time and data are necessary before making further comparisons of thinning and fertilizing as single or combined treatments. Most important to the local land manager thus far is the direct evidence that growth of crop trees can be increased by these silvicultural treatments.

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